Abstract No. peas366

Method of Linearizing the 3d L3/L2 White Line Ratio as a Function of Magnetic Moment; Application to Gold - Chrome Alloys

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Beamline(s): X11A

Introduction: We have developed a parameterization method which linearizes the relationship between local magnetic moment and the L_3/L_2 "white line" ratio as observed in electron energy loss spectroscopy or soft x-ray near edge spectroscopy. Our method applied to the electron energy loss spectra for the L edges of Cr in a Au matrix implies that the large local moment of associated with Cr in that system is not limited to Cr sites but extends into the Au. This would, in turn, imply that the addition of Cr to Au results in an enhancement of Au 5d hole count. We do observe an enhancement of the Au 5d hole count with increasing Cr concentration, by X-ray near edge spectroscopy of the Au $L_{3,2}$ absorption edges.

Methods and Materials: We made well characterized, annealed alloys of 20 atomic % Cr and 40 atomic percent Cr in a gold matrix. The alloys were the expected fcc structure, with a decreasing lattice constant as the Cr concentration increased. We measured the Au $L_{3,2}$ edges for pure Au, $Au_{0.8}$ $Cr_{0.2}$, and $Au_{0.6}$ $Cr_{0.4}$ using Si (111) monochromator crystals at the X-11 beam line. The pure gold was measured in transmission, and the alloys by the electron yield method.

Results: Our linearization method is based on an extrapolation of the theory of Thole and Van der Laan[1,2]. We find that for first row transition metal compounds in which the 3d occupation number N is less than 9, and one compares compounds of the same element, the L_3/L_2 ratio of the 3d transition metal (TM) is linearly proportional to a function F(m) of the local projected spin moment where one has the following relationship:

1. $F(m) = m^2/ (10 - N)$

This relationship was found to markedly linearize white line ratio versus moment data for a large number of oxides and metals[2]. However, applied to gold chrome alloys and using our electron energy loss (EELS) results for the CR L edges in that alloy system[3], our linearization method would imply that the large local moment on Cr atoms in such alloys[4] extends into the Au matrix. This would in turn imply a marked enhancement of the Au 5d hole count. We indeed find a systematic enhancement of the area under the Au X-ray near edge $L_{3,2}$ absorption spectrum, which increases systematically with Cr concentration, in agreement with predictions of our linearization method.

Acknowledgments: We acknowledge the help of the X-11 beam line staff. Also, the concept of the linearization method arose from previous results obtained at the U1A line. We acknowledge financial support from the Department of Energy, under DOE contract No. DE-FG05-89-ER45384.

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